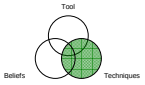
SBS 11 Technique
Total Productive Maintenance (TPM)

…Building Strategic Advantage through Enterprise Wide Improvement…



Welcome to Simpler Business System Total Productive Maintenance. TPM is A Key Enabler For Flow & Therefore Transformation. This module provides you with the Technique foundations necessary to utilize the principles of TPM within basically any process where equipment plays a critical role. Most all of us have used this tool in manufacturing but we should consider it equally valuable in service and military sectors. Equipment failures in these sectors have ramifications that dwarf the repercussions that we normally consider in the manufacturing environment. In healthcare and military, many times failures to have equipment available when needed is a life threatening situation.

Some key points for TPM in this module:

1. TPM is a subset of the Corrective Action Process – it's about fixing stuff permanently or preventing it from happening initially.

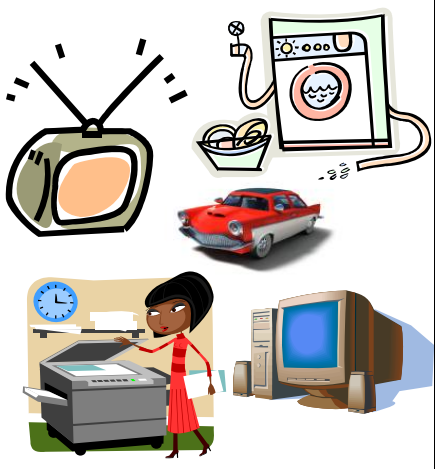
2. TPM in its broader sense is a huge undertaking where machine kaizen (rapid improvement events at the first line level) is the working arm to continuous progress toward building the whole body of knowledge and actions.

3. TPM can stand alone but lean transformations will struggle without TPM. In transformations, we often think in terms of building pilot areas to showcase successes and develop the proper working habits. This approach works well for TPM where it will fit seamlessly into model cell development to function as a successful pilot for TPM expansion.

4. Most operations struggle with kicking off OEE (overall equipment effectiveness) with their first introduction. This module is written with this in mind focusing on availability as an initial metric and expanding into the performance and quality portions of OEE only after equipment uptime is under control.

How Relevant is TPM to your Life?

- Almost All Aspects of our Lives rely on Equipment.
- Whatever Sector you are in:
  - What is the key Equipment?
  - What equipment starts the Flow?
  - How Much I.T. do we have?
- Factory, Office, Hospital, Service Operation?



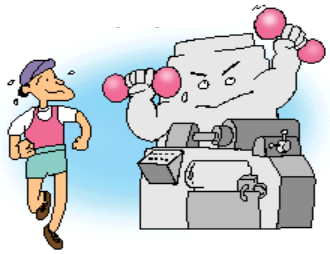
List the key equipment you need to sustain your Family.

Do the exercise in the foot stomper with the team

Whether you are working in a factory, office hospital or in the service industry you will have equipment that can effect flow.

Why is TPM more vital in Flow Processes?

- Equipment contributes to Flow or stops it.
- Dependable equipment is the purpose of TPM.
- Performing just the task needed, when you need it.
- Upkeep involving all.



TPM Frees time to do other Stuff

Simpler ®

3

Tool
Beliefs
Techniques

In many Transformations the Maintenance people are required to make many changes –we need to free up their time. Typically Leaders spend a lot of time on equipment issues. TPM frees up this time.

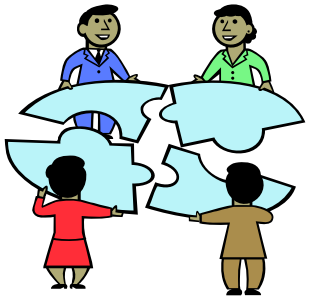
Equipment downtime is a major cause of productivity loss.

Good examples include such items as “how many times do nurses make trips to patient rooms to reset alarms?” “How much overtime is required to make up the lost production from downtime?” “How much overspeed is cooked into the run time to make up for downtime?” These examples either take away from the time to perform value added tasks or they result in paying for a higher rate of output than is actually needed (both are productivity losses).

What does dependable equipment really mean? It doesn’t mean that it runs all the time (perhaps overproduction) but that it is working properly when it’s needed and producing the needed result 100% of the time in operation.

Involve the Team.

- TPM can only be achieved through Partnership
- We need to build the right culture
- Users and maintenance together can take actions to create TPM



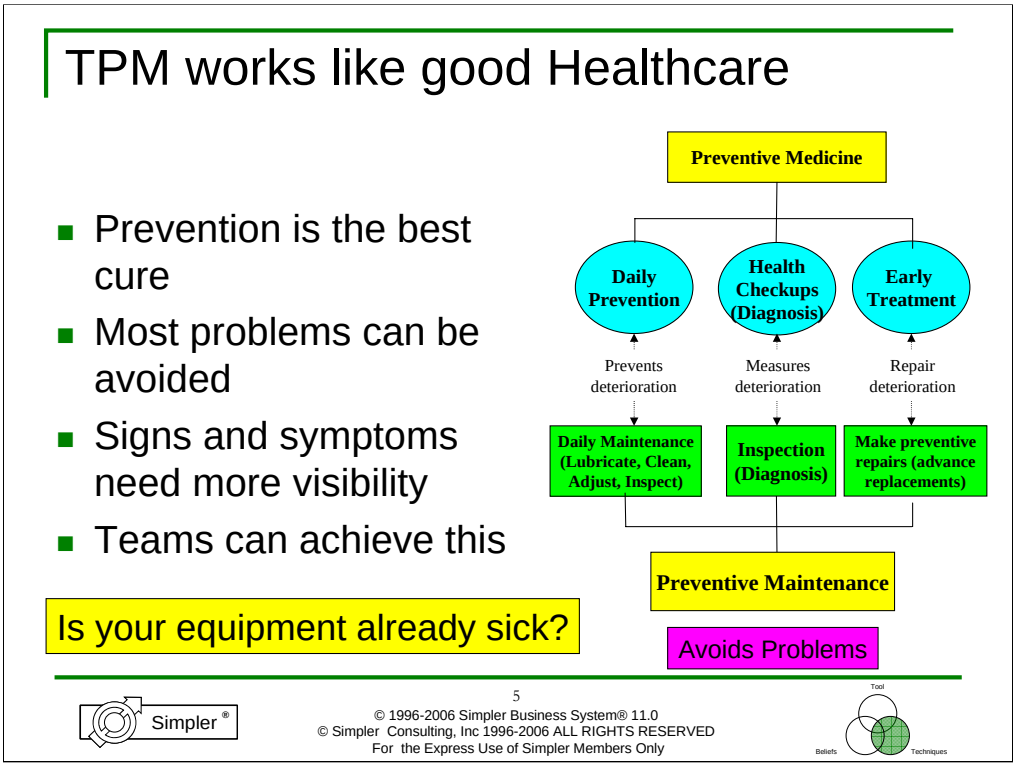
Owner operators + maintenance people = Less downtime

So what's the right culture? Autonomous maintenance owned by the operators and the maintenance personnel at the first line level.

•Stopping equipment failures before they occur

•Understanding that technical preventative maintenance is normally performed by maintenance people but equipment losses are many times caused by the operators (i.e./improper set-up or equipment operation).

•Only by joining these groups to a common end goal can the problems by solved.



The health care segment should like this analogy but everyone can identify with it. This slide puts preventative maintenance in terms that most everyone has experience.

Making advance replacements is a mathematical reliability calculation and the technique is worth detailing for board work during an event. Any scientific calculator will get the job done. You'll need e(exp x) and ln (log base e) functions.

First a few terms:

Maintainability mean time to repair = (sum of downtime for repair)

Number of Repairs

MTBF mean time between failure = Total running time

Number of failures

R(t) Reliability = e (exp)-yt (Probability an item will not fail before time t.) Y = 1/MTBF

Example: 6 OR (operating room) lamps are operated for 1000 hours. One lamp fails in 600 hours and another fails in 700 hours. Therefore: 4(1000) + 600 + 700 = 5300 hours.

MTBF = 5300/2 = 2650 hours/failure

Y = 1/2650 = .00037735 failures per hour

R(@ 1000 hrs) = e (exp) (-.00037735 x 1000) = 68.6% (this is the reliability of the lamps at 1000 hrs)

Note: e (exp)-Yt = R and an equiv. way of expressing it is:

ln R = -Yt (If you wanted reliability of 90% (ln of .9) then all of the lamps would need to get advance replacements at:

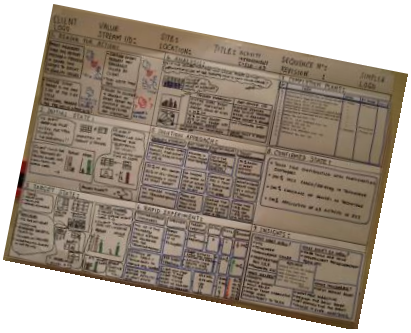
ln (.9) = (-.00037735) x t

t = (-.10536)/(-.00037735) = 279 hrs

For critical operations, this may very well be the solution of choice.

Implement TPM via your RIE program

- Use your future state to decide "Key Equipment"
- Use an A3 to structure the event
- Study equipment downtime history
- Target 50% improvements in uptime
- Determine gap information



A TPM Event is a Problem Solving Event For Equipment

Measure “Availability”

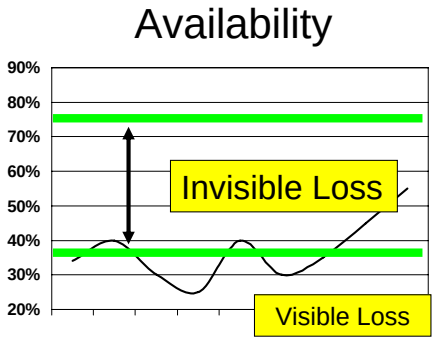
- Availability “when needed, at spec”
  - Availability (%) = Actual available time / scheduled time
  - Can be measured at any level (ie cell, value stream, facility)
- Example Calculation
  - 480 minutes in the working day
  - Minus 20 min. breaks, minus 15 min. cleanup and preventive maintenance = 445 min. of scheduled time
  - If there then were 45 minutes of machine downtime during that day
  - Availability (%) = (445 – 45) / 445 = 90%
- Goal: 100% available when needed

This arithmetic must be done & owned by the people who work the equipment

As indicated, a great starting point is to focus on the availability metric. What to include in downtime for the availability metric will be discussed in detail later during discussion of the 6 major losses.

Capture visible and invisible losses

- **Invisible**
  - Usually largest loss of time
  - Unrecorded (normal)
  - Many small failures
  - Accepted as part of the job
  - Not accepted for failure by bosses
- **Visible**
  - Major unexpected failure
  - Everybody knows (it's not working)
  - Tracked by maintenance
  - Logged
  - Accepted for process failure by bosses



How much is each type costing us vs. our true North Metrics?

Getting brief stops recorded at the first line level should be a high priority. It is usually much higher than most people think and they get ignored. Put dollar signs with the lost time to get it the attention deserved.

Someone may well bring up that speed losses are invisible also. True but not part of the availability metric. Conquer downtime first and speed losses will be accounted for when the site is ready for engagement with OEE metrics.

Take it to as new condition & improve

- Clean up to reveal problems
- Fix problems
- Improve better than new
  - e.g. paint white to spot leaks
  - Make covers clear & see through
  - Remove features not used
  - Visual aids improvement
  - Safety devices
  - Jidoka
  - Implement visual methods

The identification of issues and losses from production are used to complete the "Gap Analysis" of the A3

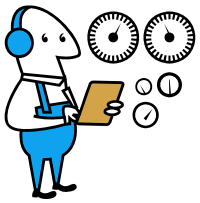
Visual Management

Machine

- Make it easy to see normal/abnormal
- See critical information in the shortest time
- Remove obstacles to seeing

Data

- Track progress visually
- Track losses
- Trends & limits
- Completed by user



See at a glance – Frees up your time

If they don't measure it, they won't get it. Establish TPM boards to visually present information showing if they are winning or losing. Visual management "information" should be combined with check sheets and standards discussed later.

The New Roles of Maintenance & Users

Users

- Safety & proper orientation
- Simple Maintenance
  - Lubrication
  - Cleaning
  - Use natural senses for early detection

Maintainers

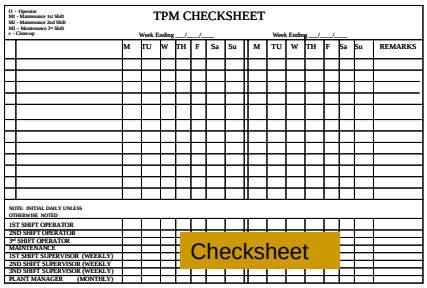
- Detailed knowledge & history
- Scheduled maintenance
- Major Overhaul
- Upgrades

Partnership Approach

An additional role that may be appropriate for users is “tightening”. This can be very useful but good visual standards should be incorporated to be effective along with making it part of the checksheet. One solid goal of the partnership approach is to not only build this culture but to also improve skill levels. Therefore, maintainers can take on the role of training getting users more involved.

TPM Check-sheets & Standards

- Check sheets include what tasks, how often they are performed, and who is responsible.
- Standards show where and how the check is done.
- With both, visual management should be a the standard



Checksheet


Combined checksheet and standard

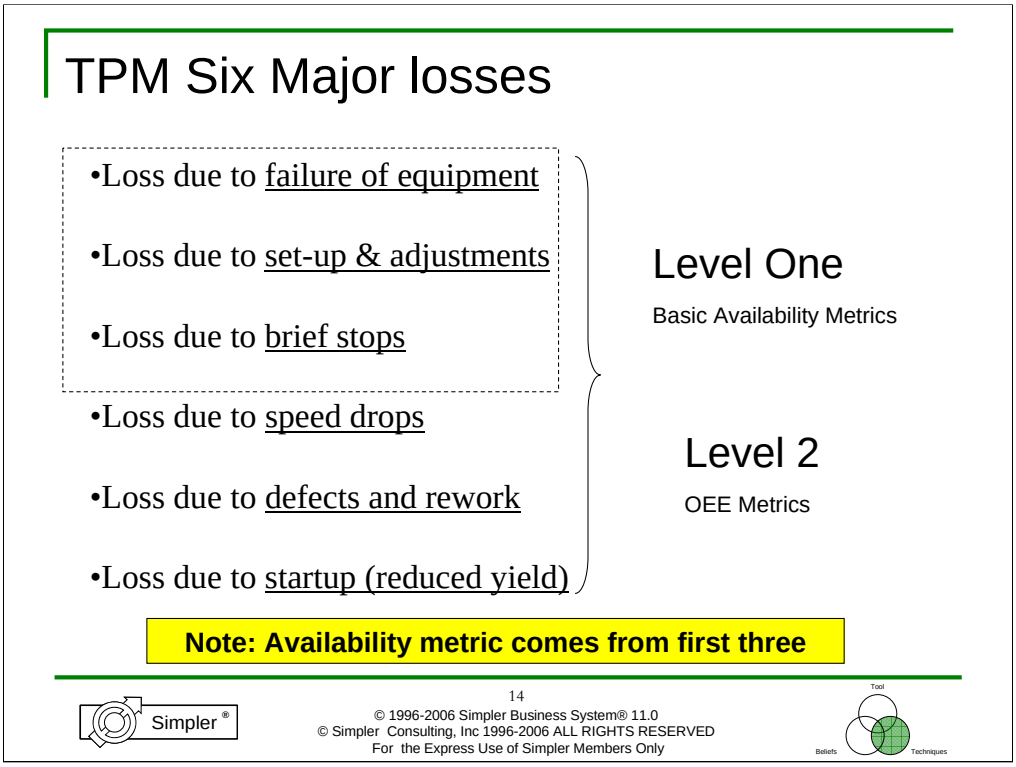

Lubrication standard

Check sheets and standards should be part of the visual management board. Although standards should be laminated and permanent, checksheets should be hard paper copies until data response time is shortened. Example: If it's a one week sheet, the client erases the accountability every week.

Seven Steps to Autonomous Maintenance

Step	Description	Activities
1	Clean and Inspect	Eliminate all dirt and grime on the equipment, lubricate, tighten bolts, nuts and screws. Find and correct problems
2	Eliminate problem sources and inaccessible areas	Correct sources of dirt and grime; remove obstacles, improve accessibility for cleaning and lubrication. Shorten the time it takes to clean and lubricate
3	Draw up cleaning and lubricating standards	Write visual standards that will ensure that cleaning, lubrication and tightening can be done efficiently (Make a schedule for period tasks)
4	Conduct general inspections	Conduct skills training and general use Inspections to find and correct slight abnormalities in the equipment
5	Conduct Autonomous inspections	Prepare standard check sheets for autonomous inspections. Insure that these inspections are performed
6	Standardize through visual workplace management	Standardize and visually manage all work processes. Examples of standards needed ▪Cleaning, lubrication and inspection ▪Material flow ▪Data recording methods ▪Tools Management
7	Implement Autonomous maintenance	Develop company policies and objectives; make improvement activities part of everyday activities. Keep good data, analyze it, use to improve efficiency of equipment

This slide pulls all of the previous slides together and details the work of equipment “kaizen”.



Focusing on unexpected major equipment failures, set-up losses, and brief stops will address the actual machine downtime causes. Follow the corrective action logic – no more than three on their plate, fixing them one at a time. All six of the major losses can only be addressed within TPM using the OEE metric but don't get sidetracked here. The CA process and SMED work fine for addressing the other losses. Working level one first is recommended.

Focus on availability with this slide.

Goals for the 6 major losses

Type of Loss	Goal	Remarks
Loss due to failures	0	Target 0 for all equipment
Loss due to setup& adjustments	Minimize	As brief as possible for all machines; apply SMED
Loss due to speed drops	0	Difference between actual speed and ideal speed should be 0. Should strive to improve equipment so it **can be** operated at greater than rated speed without quality loss. (Future capacity)
Loss due to brief stops	0	Target 0 for all equipment
Loss due to defects and rework	0	Must be within tolerance range (for example, 100-300 PPM) - think zero defects for customers.
Loss due to startup (yield)	0	Target first part is a good part at startup

Note the underscored “can be” relative to speed losses. Caution on increased speed resulting in quality losses or overproduction. Sometimes you can operate slower to get more.

The main talking point with this slide is to ask how many people think zero defects for customers is achievable or if it’s just a state of mind goal to shoot for. Most all will say it’s not an achievable goal but yet it has been achieved by numerous companies (reference George’s “Creating Lean” presentation). TPM zero losses is not different. If participants do not believe these goals are possible, they will continue to believe that some downtime is inevitable and therefore OK. Reinforce “every egg a bird”.

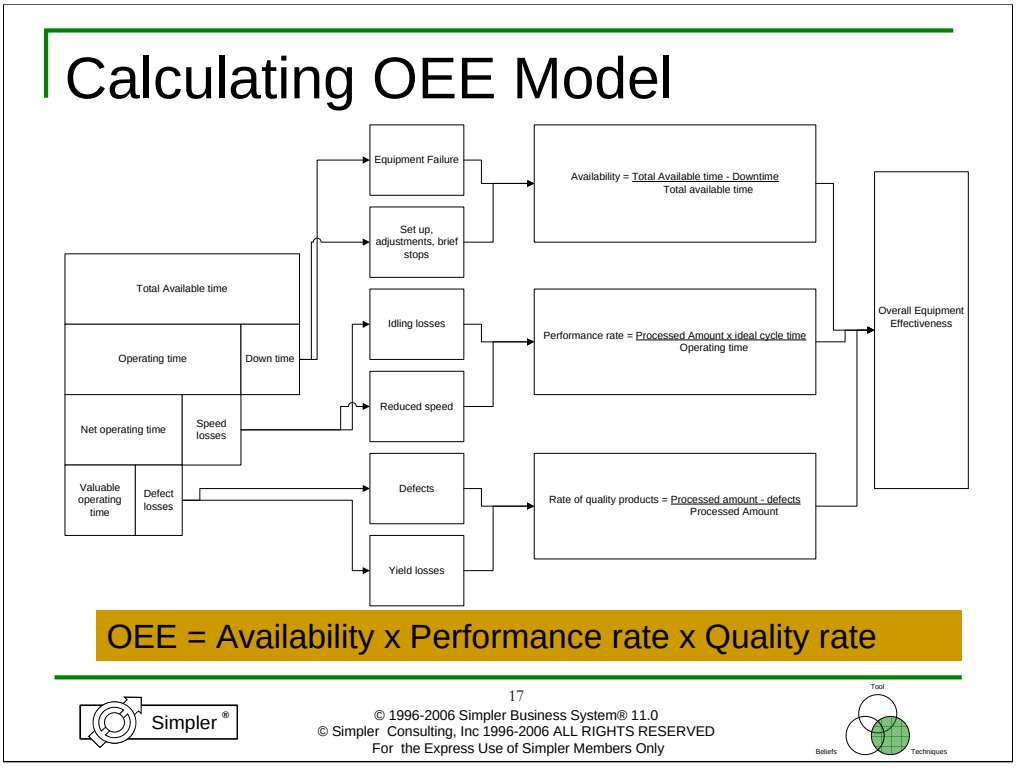
Overall Equipment Effectiveness (OEE)

- OEE broadens the corrective action effort to process level
  - Equipment performance and process quality are pulled together under the umbrella of TPM.
  - Don't expand beyond the availability metric before you are capable of sustaining first level TPM.

Don't outrun your headlights

A question commonly asked is "what's the target for availability before moving forward?" Unfortunately, the answer is not straight forward. The biggest factor for this uncertainty is number and complexity of changeovers. 80% may be great or it may leave much to be desired. For example, a fully automatic four color screen printing machine typically spends 80% of a shift in changeover but far exceeds the capacity of manual machines running for the entire shift.

This is a good stopping point for not getting too involved with the OEE metric.



Shows the OEE model, breakdown of the six major losses, calculations, and the time losses by cause for each. Availability (think % uptime) and quality (percent good stuff) are straight forward but performance rate is a little more difficult to understand. The next slide focuses on only performance rate.

Total available time is less planned downtime such as breaks and clean-up.

Understanding Performance Rate

- Performance rate = Operating speed rate x Net operating rate
  - Operating speed rate = (ideal cycle time)/(actual cycle time)
  - Net operating rate = (processed amount x actual cycle)/(operation time)

The net operating rate measures the maintenance of a given speed over a given period. It calculates losses resulting from those that go unrecorded on the daily logs.

- Performance rate = $\frac{\text{processed amount x ideal cycle time}}{\text{operation time}}$

Performance rate measures speed losses and unaccounted for downtime.

Processed amount x actual cycle = actual processing time

For those that want to see how the performance rate calculation is derived:

Performance rate = $\frac{\text{processed amount x actual cycle}}{\text{operation time}} \times \frac{\text{ideal cycle time}}{\text{actual cycle}}$

$= \frac{\text{processed amount x ideal cycle time}}{\text{operation time}}$

Net operating rate now links back to previous comments relative to accountability of unrecorded lost time. At this point, brief stops data should already be included in the availability calculation. Net operating rate will capture unrecorded data and there likely will be some even if operators are doing a good job of logging.

OEE Calculation example

Total available time = (60 minutes x 8 hours) – planned downtime
Recorded downtime for the shift = 60 minutes >>>>Downtime components:

Set-up loss (20 min.)
Minor stops: (60 min)
Major stops: (20 min.)
Adjustments (20 min.)
Rework (3% rejects)

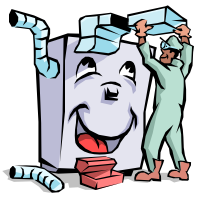
Operating time (TPM) = 460 minutes (w/2 ten minute breaks) – downtime and set-up losses = 340 min.
Output for the shift = 325 complete tasks
Availability = (340/460) x 100 = 74%
Ideal cycle time = 0.7 minutes per task
Actual cycle time = 0.8 minutes per task
Operating speed rate = (0.7/0.8) x 100 = 87.5%
Net operating rate = {(325 complete tasks x 0.8)/(340 minutes)} x100 = 76.5%
Note: (1 - net operating rate) indicates loss due to unrecorded losses.
Performance rate = 87.5% x 76.5% = 67%
Quality (nondefective) rate = 97.0%

Overall effectiveness = 74% x 67% x 97% = 48%

Straight forward example of OEE calculation that could apply to virtually any sector.

Developing an Organization wide TPM Program

- Line to mission/Transformation A3
- Management committee & involvement
- Start with a pilot area
  - Make it a model cell with model TPM
  - Use A3 thinking for each TPM event
  - Run TPM RIE,s along side transformations
- TPM will deliver many improvements



Equipment is a reflection of the organization that owns it

A site wide TPM program is a big step that will require significant management support. Let everyone know what's coming – a site wide meeting. The approach identified here is to introduce Availability with a model area, expand the model area to encompass OEE when downtime is under control, then introduce availability into another area. Gain successes before you move on. Spread TPM throughout the organization in this manner.

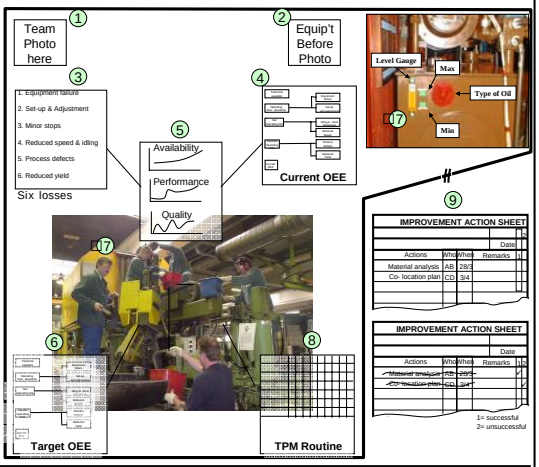
Even Better

Avoidance is the best course

- Before you buy or build, ensure equipment is
  - Right sized
  - Easy to use
  - Easy to clean
  - Easy to maintain
  - Quick to set up or change over
- Think whole lifecycle cost
- Use 3P “right sized” equipment design events

Smart Purchasing/Smart Design is best Prevention

TOTAL PRODUCTIVE MAINTENANCE



Step 1 Assemble the right team
- Select members who are 'experts' for the equipment we are improving
- Remember - there is no rank consensus is our aim
- All team members are experts in their own subject/ job involve departments that plan, design, use & maintain the equipment. Involve managers & suppliers too.

Step 2 Go to the piece of equipment and take a 'before' photo
- Ensure that the 'as-is' condition is recorded.
- Record the current status for each of the six losses

Step 3 Record the status against the 6 major losses
- Team lists observations of each loss on post-its & take photo's

Step 4 Calculate the Overall Equipment Efficiency (OEE)
- Use sheet to calculate as-is OEE measure

Step 5 Create a visual measures of equipment performance
- Availability
- Performance
- Quality

Step 6 Collect historical data and set targets
- Asses the history of the equipment
- In the light of the current OEE, customer demand & required maintenance schedule set an OEE target

Step 7 Get it working well
- Clean the equipment and do a detailed assessment of condition
- Plan & undertake refurbishment as a team
- Apply visual means so future abnormalities are immediately obvious. (Paint mark bolts, remove covers, add sight glasses, etc. etc.)
- Take pictures & display on TPM Cart

Step 8 Establish a routine for problem prevention
- Develop checklists for users (minor daily checks / maintenance)
- Develop planned maintenance schedule by support staff
- Develop an ordering plan for spares and consumables

Step 9 Define improvement targets for major changes required
- Transfer major issues to the team improvement action sheet

Step 10 Create daily routine required for the habit to be formed
- Allocate responsibilities and check progress until habits are formed
- Account for time required to do TPM in planning assumptions
- Ensure OEE figure is always displayed and topical

Step 11 PDCA
- Add TPM activity to the daily checks to confirm process stays in place over time.

Before starting……please remember :
- We are aiming for one piece flow.
- Value cannot flow if equipment is down.
- We have an organisation full of talented people, we do not want to waste valuable time because of equipment.
- Work should be easier faster & more fun as a result of doing this

Process rules
- Follow the steps and work as a team - involve the team who do the work.
- Use clear writing, pictures and the standard forms provided

Issue 1

One pager for using OEE as a metric for TPM.